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A multi-subsystem fuzzy DEA model with its application in mutual funds management companies' competence evaluation

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Abstract

This paper proposes a multi-subsystem fuzzy data envelopment analysis (MFDEA) model to evaluate mutual funds management companies' core competence which is apparently characterized with both qualitative factors and quantitative factors. As the first attempt of core competence analysis of mutual funds management companies in a financial market, we evaluate how close the mutual funds management companies are to the best practices frontier, and analyze how they should manage their funds. An empirical study of 32 mutual funds management companies in China leads to a meaningful analysis and some management insights. The approach can also be applied to many other hard assessment and evaluation problems.

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Keywords: Mutual funds management company; core competence; multi-subsystem fuzzy data envelopment analysis (MFDEA).

1. Introduction

Mutual funds have been one of the most popular investment instruments in China for the past 10 years. There are more than 60 mutual funds management companies in China today. The competition is very serious among the mutual funds management companies. Active investment management helps to keep markets efficient and to ensure the flow of funds to the most successful enterprises, which plays an important role in the allocation of resources within the economy. Therefore, management of mutual funds industry deserves much more attention, especially for the eveluation of the funds management companies' core competence.

The core competence evaluation is actually a kind of multi-criteria evaluation problem. In this paper, we propose a multi-subsystem fuzzy data envelopment analysis (MFDEA) model to eveluate mutual funds management companies' core competence from both qualitative factors and quantitative factors. Each company is regarded as a system with two subsystems. Our purpose is to optimize each company's relative efficiency of its whole system and two subsystems at the same time. While considering the whole system's relative efficiency, tradeoffs between the two subsystems are made. A fuzzy membership function for types of funds is embedded into inputs and outputs to allow that each mutual funds management company may manage one or more types of funds with different risk and

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return features, so as to make sure the evaluation is carried out with an equal premise.

DEA is an excellent system management tool. For a detailed discussion on the original DEA model, readers can refer to Charnes and Cooper [1]. There have been several studies on mutual fund investment performance in which DEA methodology is applied. Among those studies, Murthi, Choi and Desai [2], Choi and Murthi [3], McMullen and Strong [4], Morey [5], Galagedera and Silvapulle [6], Luo and Wang [7], Zhao, Lai and Wang [8] , Zhao and Wang [9] are referred. The motivation of the present study is derived from the circumstances faced by the mutual funds management companies that performance evaluation should not be restricted solely to an assessment of investment performance.

To the authors' knowledge, this is the first paper to analyse and examine the core competence's relative efficiency of mutual funds management companies in a financial market. From an academic perspective, the particular contribution of this paper lies on the proposal of MFDEA model, as an improvement of fuzzy DEA model. With the aid of MFDEA, we evaluate how much the mutual funds management companies' core competence differ from each other, and analyze how they should manage their funds. An empirical study of 32 mutual funds management companies in China leads to a meaningful analysis and some management insights. This approach can be also applied to solve many other hard assessment and evaluation problems.

2. Core competence analysis for mutual funds management companies

Mutual funds management companies are institutions resorting expert knowledge and experience with capital collected from investors to make investment decisions in a scientific portfolio principle and to pursue assets increment so as to benefit fund holders as much as possible.

The paper "The core competence of the company" [10] which is regarded as a classical reference for the core competence, gives a definition of the core competence as follows: core competence is the knowledge accumulated in the organization, especially the knowledge how to harmonize different production skills.

According to this definition, we can divide mutual funds management companies' core competence into two parts which can be regarded as two subsystems.

2.1. Competence of investment and research

Core competence of a company should be established on the basis of core business. A mutual funds management company's core business is asset management. It gets return in course of detecting and managing risk. In this sense, one of its essential characteristics is symmetry in risk and return. Mutual funds management companies never stop measuring and appraising relationship between risk and return.

However, that is not enough. The development of return and risk is their persistence. Whether or not the performance can be persistent gives more important information about investment research competence. Meanwhile, steady investment team is important to guarantee investment performance persistence. Research is also strong surpport for investment, including production of quality research reports, design of new fund products, and hence, is powerful backing force of the core business.

2.2. Competence of marketing and service

Marketing is a basic practical activity to realize a company' s business objective and to enlarge the company's market shares continually. As for a mutual funds management company, marketing capacity influences asset scale directly, and the capacity of resisting risk indirectly. On the other hand, mutual fund industry is a finanial service industry; therefore, fund marketing capacity can be represented by the service to investors too.

Information disclosure is part of important content to represent service competence to rectify the information asymmetry, including the management of risks and costs, the main stocks and bonds invested, warehouse stock, ect. For investors, whether or not fund information is easy to get and whether or not the information is abundant and complete are important signs of the service capacity.

3. Concept model

To evaluate the core competence of mutual funds management companies, we have to make indicators clear and construct concept models with the features we extracted above.

3.1. Risk measurement

When measuring risk of mutual funds in an emerging financial market, the VaR under asymmetry Laplace distribution is an excellent tool [11]. Consequently, VaR under asymmetry Laplace distribution will be employed as a measurement of mutual funds risk in this paper.

3.2. Weight for return and risk measurement

Scales reflect funds' historical performance to some extent, further to represent managers' investment competence. Therefore, to some extent, returns weighted by scales are able to represent the mutual funds management companies' investment capacity.

Considering that scales of most equity funds are larger than those of bond funds, and that for the most time, equity funds are more profitable than the bond type of funds, if returns are only weighted by the scale, a bias will much favor equity funds and against bond funds. To avoid this, type should be qualified and employed as another weight for returns. A membership function is proposed in this paper to characterize funds' types.

A mutual funds management company always manages more than one type of mutual fund. Each type has its own risk characteristics, which determine each type's return characteristics.

Data in Table 1 shows that VaR value under asymmetry Laplace is the most distinct indicator to represent types' characteristics. Therefore, we will construct types' member function with funds' VaR value.

Table 1. Statistics of funds types' characteristics (2004~2006)

	VaR			Return of net value		
	Average	Max	Min	Average	Max	Min
Equity funds	3.54	6.60	2.10	10.19	58.19	-8.94
Balanced funds	1.01	1.61	0.88	4.08	15.38	-2.42
Bond funds	0.51	0.75	0.18	7.92	12.49	2.15

Suppose the member function to be as follows:

$$\widetilde{C} = f(x) = \begin{cases} 0, & x < 0 \\ 1, & x = 0 \\ 2 - \dfrac{2}{1 + e^{-0.1x}}, & x > 0 \end{cases} \tag{1}$$

where x is the VaR value of risk measurement. Obviously, it is a contrary sigmond function.

Fuzzy number $\widetilde{C}_i$ is employed to be another weight for returns. Suppose that mutual funds management company j manages m mutual funds, the ith fund (i=1,…,m) belongs to type f, its type fuzzy number is $\tilde{C}_f$, and the ith fund's average scale is $S_{i,t}$ during term t with absolute accumulative net value return $R_{i,t}$, then the company's return capacity can be defined as:

$$RG_{j,t} = \frac{1}{\sum_{i=1}^{m} S_{i,t}} \sum_{i=1}^{m} S_{i,t}(\tilde{C}_f R_{i,t}),\ i = 1, \cdots, m \tag{2}$$

where $\tilde{C}_f$ is the average value of all the funds' fuzzy numbers in type f. Similarly, the following is an appropriate measurement for a company j's risk at term t

$$RiskG_{jt} = \frac{1}{\sum_{i=1}^{m} S_{it}} \sum_{i=1}^{m} S_{it}(\tilde{C}_f \times VaR_{it}),\ i = 1, \cdots, m \tag{3}$$

where $\widetilde{C}_f$ is the fuzzy number of type f, VaR_{it} is fund i's VaR value during term t.

3.3. *Stability of team*

The management team's stability is very important for funds management companies. In order to measure managers' stability, the average tenure of managers in company j is denoted as Y_j. The bigger Y_j is, the better the company j's stability is.

3.4. *Concept models for system and subsystems*

According to the analysis of Section 2, investment research subsystem focuses on asset management competence and its supporting factors, especially whether or not able to get better performance with lower risk level and cost; marketing service subsystem focuses on competence and efficiency in market development, whether or not certain cost can produce the corresponding market shares' expansion.

Since mutual funds management companies' core competence evaluation is actually the synthesis of two subsystems evaluation, concept models can be set up following the law of efficiency investigation as Table 2.

Table 2 Concept models for fund companies' core competence evaluation.

Company system	Inputs	Outputs
Subsystem of investment and research (I)	1) Weighted VaR during term 1 2) Weighted VaR during term 2 3)The reverse of fund managers' average tenure	1) Number of funds in charge 2) Number of types covered 3) Products innovation speed 4) Weighted return during tem 1 5) Weighted return during tem 2
Subsystem of marketing and service (S)	1) Cost of marketing service	1) Scale growth 2) Average initial subscription scale 3) Information service quality 4) Total shares

3.5. *Disposal of qualitative indicators*

Among the criteria in the subsystem of marketing and service, the quality of information service is a qualitative variable that needs to be quantified in the evaluation. Expert knowledge and judgement are applied in the disposal of qualitative criterion here. Suppose the appraisal remark set to be V={V1 ,V2 ,V3 ,V4, V5}={very good, good, general, bad, very bad} ($x \in V$) to measure the information service quality. The membership function is defined as:

$$f(x) = \begin{cases} 1, & x = \text{"very good"} \\ 0.8, & x = \text{"good"} \\ 0.5, & x = \text{"general"} \\ 0.3, & x = \text{"bad"} \\ 0, & x = \text{"very bad"} \end{cases} \tag{4}$$

where $x \in V$. Transforming V to $\widetilde{V} = \{1, 0.8, 0.5, 0.3, 0\}$ by function $f(x)$, suppose the expert investigation result to be

$R = \{r_1, r_2, \cdots, r_5\}$, where

$$r_i = \frac{\text{the number of experts agree with comment } i}{\text{the number of all experts take part in investigation}} \quad (i = 1, \cdots t), \tag{5}$$

then $\widetilde{F} = \widetilde{V}R^T$ is the fuzzy score of the criterion.

4. MFDEA model

4.1. *Fuzzy DEA Model*

The classical DEA model is fit to deal with only accurate numbers, not fuzzy numbers. Suppose that there are n DMUs and each DMU_j $(j = 1,2,\cdots,n)$ has m inputs and s outputs, Lertworasirikul et al. [12] proposed the following fuzzy DEA model based on BCC model:

$$\begin{aligned} &\max_{\boldsymbol{\omega},\boldsymbol{\mu}} \boldsymbol{\mu}^T \mathbf{y}_0, \\ &\text{s.t.} \quad \boldsymbol{\omega}^T \tilde{\mathbf{X}} - \boldsymbol{\mu}^T \tilde{\mathbf{Y}} \geq 0, \\ &\qquad \boldsymbol{\omega}^T \tilde{\mathbf{x}}_0 = 1, \\ &\qquad \boldsymbol{\omega}, \boldsymbol{\mu} \geq 0, \end{aligned} \tag{6}$$

where

$$\tilde{\mathbf{X}} = \begin{bmatrix} \tilde{x}_{11}, \tilde{x}_{12}, \cdots, \tilde{x}_{1n} \\ \tilde{x}_{21}, \tilde{x}_{22}, \cdots, \tilde{x}_{2n} \\ \cdots, \ \cdots, \ \cdots \\ \tilde{x}_{m1}, \tilde{x}_{m2}, \cdots, \tilde{x}_{mn} \end{bmatrix}, \quad \tilde{\mathbf{Y}} = \begin{bmatrix} \tilde{y}_{11}, \tilde{y}_{12}, \cdots, \tilde{y}_{1n} \\ \tilde{y}_{21}, \tilde{y}_{22}, \cdots, \tilde{y}_{2n} \\ \cdots, \ \cdots, \ \cdots \\ \tilde{y}_{s1}, \tilde{y}_{s2}, \cdots, \tilde{y}_{sn} \end{bmatrix},$$

$\tilde{\mathbf{x}}_{ji}$ and $\tilde{\mathbf{y}}_{jr}$ are the fuzzy inputs and fuzzy outputs of DMU_j $(j = 1,2,\cdots,n)$. $\boldsymbol{\omega}$ and $\boldsymbol{\mu}$ represent weight vectors of input in m dimension and output in s dimension. DMU0 is the target DMU from DMU_j $(j = 1,2,\cdots,n)$.

Fuzzy DEA is a nonlinear program, Lertworasirikul et al. introduced an approach to transform fuzzy BCC model into the following linear program by use of probability and $\alpha-\text{cut}$:

$$\begin{aligned} &\max_{\boldsymbol{\omega},\boldsymbol{\mu}} (\boldsymbol{\mu}^T \mathbf{y}_0)^U_\beta, \\ &\text{s.t.} \quad (-\boldsymbol{\omega}^T \tilde{\mathbf{X}} + \boldsymbol{\mu}^T \tilde{\mathbf{Y}})^L_\alpha \leq 0, \\ &\qquad (\boldsymbol{\omega}^T \tilde{\mathbf{x}}_0)^U_{\alpha_0} \geq 1, \\ &\qquad (\boldsymbol{\omega}^T \tilde{\mathbf{x}}_0)^U_{\alpha_0} \leq 1, \\ &\qquad \boldsymbol{\omega}, \boldsymbol{\mu} \geq 0, \end{aligned} \tag{7}$$

where α, α_0, $\bar{\alpha}_1$, $\bar{\alpha}_2$ avail themselves of $\alpha-\text{cut}$ level to convert the corresponding fuzzy numbers into exact numbers. Hence, model (7) converts the fuzzy numbers into the corresponding interval numbers. It is easy to solve. For each interval number, its' upper boundary is denoted by "U" and its lower boundary is denoted by "L". For example, $(\boldsymbol{\mu}^T \tilde{\mathbf{y}}_0)^U_\beta$ represents the upper boundary of fuzzy number $\boldsymbol{\mu}^T \tilde{\mathbf{y}}_0$ on the level of $\beta-\text{cut}$. Other denotations can be interpreted correspondingly.

4.2. *DEA model with subsystems*

Suppose that there are *n* mutual funds management companies. Let the inputs of the investment research subsystem and the inputs of the marketing service subsystem be denoted as sets $IIndex^I$, $IIndex^S$, and let their outputs be denoted as sets $OIndex^I$, $OIndex^S$. Let $A=\{I, S\}$ denote the set of subsystems. $\mathbf{X}^a_j = \{x^a_{ij}\}$ $(i \in IIndex^a)$ $(a \in A)$

represents the inputs of DMU_j $(j=1,2,\cdots,n)$ in subsystem a $(a\in A)$, and $\mathbf{Y}_j^a=\left\{y_{rj}^a\right\}$ $(r\in OIndex^a)$ $(a\in A)$ represents the outputs of DMU_j $(j=1,2,\cdots,n)$ in subsystem a $(a\in A)$. The corresponding weights are $\boldsymbol{\omega}^a$, $\boldsymbol{\mu}^a$ $(a\in A)$. The corresponding weights are $\boldsymbol{\omega}^a$, $\boldsymbol{\mu}^a$ $(a\in A)$. With the CCR model [13], we model the investment research subsystem and the marketing service subsystem respectively. Program (8) is for the subsystem of investment research. Another system can be modeled by linear program (9).

$$\begin{aligned}&\max \boldsymbol{\mu}^{IT}\mathbf{Y}_0^I,\\&\text{s.t.}\quad \boldsymbol{\omega}^{IT}\mathbf{X}_j^I-\boldsymbol{\mu}^{IT}\mathbf{Y}_j^I\geq 0,\quad j=1,2,\cdots,n,\\&\qquad \boldsymbol{\omega}^{IT}\mathbf{X}_o^I=1,\\&\qquad \boldsymbol{\omega}^{IT},\ \boldsymbol{\mu}^{IT}\geq 0.\end{aligned}\tag{8}$$

$$\begin{aligned}&\max \boldsymbol{\mu}^{ST}\mathbf{Y}_0^S,\\&\text{s.t.}\quad \boldsymbol{\omega}^{ST}\mathbf{X}_j^S-\boldsymbol{\mu}^{ST}\mathbf{Y}_j^S\geq 0,\quad j=1,2,\cdots,n,\\&\qquad \boldsymbol{\omega}^{ST}\mathbf{X}_o^S=1,\\&\qquad \boldsymbol{\omega}^{ST},\ \boldsymbol{\mu}^{ST}\geq 0.\end{aligned}\tag{9}$$

To evaluate a mutual funds management company's core competence, a natural thought is to begin with the evaluation of each subsystem, followed with averaging the scores of the two subsystems, which can be expressed by the following linear program:

$$\begin{aligned}&\max \sum_{a\in A}\boldsymbol{\mu}^{aT}\mathbf{Y}_0^a,\\&\text{s.t.}\quad \boldsymbol{\omega}^{aT}\mathbf{X}_j^a-\boldsymbol{\mu}^{aT}\mathbf{Y}_j^a\geq 0,\quad j=1,2,\cdots,n,\\&\qquad \boldsymbol{\omega}^{aT}\mathbf{X}_o^a=1,\\&\qquad \boldsymbol{\omega}^{aT},\ \boldsymbol{\mu}^{aT}\geq 0,\ a\in A.\end{aligned}\tag{10}$$

Thus, the system score $\sum_{a\in A}\boldsymbol{\mu}^{aT}\mathbf{Y}_0^a/\sum_{a\in A}\boldsymbol{\omega}^{aT}\mathbf{X}_0^a$ can be optimized as follows:

$$\begin{aligned}&\max \sum_{a\in A}\boldsymbol{\mu}^{aT}\mathbf{Y}_0^a,\\&\text{s.t.}\quad \sum_{a\in A}(\boldsymbol{\omega}^{aT}\mathbf{X}_j^a-\boldsymbol{\mu}^{aT}\mathbf{Y}_j^a)\geq 0,\quad j=1,2,\cdots,n,\\&\qquad \sum_{a\in A}\boldsymbol{\omega}^{aT}\mathbf{X}_o^a=1,\\&\qquad \boldsymbol{\omega}^{aT},\boldsymbol{\mu}^{aT}\geq 0,\ a\in A.\end{aligned}\tag{11}$$

However, there is a close relationship between the subsystem of investment research and the subsystem of marketing service. The main limitation of model (11) is to neglect each subsystem. We consider the following model to optimize both the whole system and subsystems coinstantaneously:

$$\begin{aligned}&\max \sum_{a\in A}\boldsymbol{\mu}^{aT}\mathbf{Y}_0^a,\\&\text{s.t.}\quad \sum_{a\in A}(\boldsymbol{\omega}^{aT}\mathbf{X}_j^a-\boldsymbol{\mu}^{aT}\mathbf{Y}_j^a)\geq 0,\quad j=1,2,\cdots,n,\\&\qquad \boldsymbol{\omega}^{aT}\mathbf{X}_o^a=\beta^a,\\&\qquad \boldsymbol{\mu}^{aT}\mathbf{Y}_0^a\leq\beta^a,\\&\qquad \sum_{a\in A}\beta^a=1,\\&\qquad \beta^a\in[0,1],\ a\in A,\\&\qquad \boldsymbol{\omega}^{aT},\ \boldsymbol{\mu}^{aT}\geq 0.\end{aligned}\tag{12}$$

The objective of this program is to optimize DMU_0's relative efficiency in the system $\sum_{a\in A}\boldsymbol{\mu}^{aT}\mathbf{Y}_0^a/\sum_{a\in A}\boldsymbol{\omega}^{aT}\mathbf{X}_0^a$ and in the two subsystems $\boldsymbol{\mu}^{aT}\mathbf{Y}_0^a/\boldsymbol{\omega}^{aT}\mathbf{X}_0^a$ $(a\in A)$, respectively. $\sum_{a\in A}\beta^a=1$ in model (12) ensures that each subsystem's relative efficiency score is less than 100%, so as to satisfy the definition of classical efficiency. The introduction of

parameter β^{a} is based on two reasons: (1) to make tradeoff between the subsystems; (2) β^a allows experts to use their knowledge/judgement. For example, if experts think the subsystem of investment research more important than the another, then let $\beta^I > \beta^S$; similarly, if β^{a} is equal to $\frac{1}{2}$, then it represents equal opinion of experts on the two subsystems. Generally, β^{a} should not be valued as 0 or 1 because it means one of the subsystems is totally ignored. This is unreasonable. Moreover, the model guarantees the whole system's relative efficiency if both the subsystems are relatively efficient. Model (12) adopts the same hypothesis of variant returns to scale with BCC model [13].

4.3. Multi-subsystem fuzzy DEA model

We combine fuzzy DEA model with multi-systems. It not only manages to settle the evaluation problems with both exact numbers and fuzzy numbers, but also manages to take into full consideration of mutual funds management companies' features as follows:

$$
\begin{aligned}
&\max((\sum_{a\in A}\boldsymbol{\mu}_1^{aT}\tilde{\mathbf{Y}}_0^a)_{\zeta}^U+\sum_{a\in A}\boldsymbol{\mu}_2^{aT}\mathbf{Y}_0^a),\\
&\text{s.t.}\quad \sum_{a\in A}((\boldsymbol{\omega}_1^{aT}\tilde{\mathbf{X}}_j^a-\boldsymbol{\mu}_1^{aT}\tilde{\mathbf{Y}}_j^a)_{\xi}^L+\boldsymbol{\omega}_2^{aT}\mathbf{X}_j^a-\boldsymbol{\mu}_2^{aT}\mathbf{Y}_j^a)\ge 0,\\
&\qquad\qquad j=1,2,\cdots,n,\\
&\quad(\boldsymbol{\omega}^{aT}\tilde{\mathbf{X}}_o^a)_{\zeta_0^a}^U+\boldsymbol{\omega}^{aT}\mathbf{X}_o^a\ge\beta^a,\\
&\quad(\boldsymbol{\omega}^{aT}\tilde{\mathbf{X}}_o^a)_{\zeta_0^a}^L+\boldsymbol{\omega}^{aT}\mathbf{X}_o^a\le\beta^a,\\
&\quad(\boldsymbol{\mu}^{aT}\tilde{\mathbf{Y}}_0^a)_{\zeta_0^a}^U+\boldsymbol{\mu}^{aT}\mathbf{Y}_0^a\le\beta^a,\\
&\quad\sum_{a\in A}\beta^a=1,\\
&\quad\beta^a\in[0,1],\ a\in A,\\
&\quad\boldsymbol{\omega}_1^{aT},\ \boldsymbol{\mu}_1^{aT},\ \boldsymbol{\omega}_2^{aT},\ \boldsymbol{\mu}_2^{aT}\ge 0.
\end{aligned}
\tag{13}
$$

5. Empirical study

The mutual funds industry in China has been developing rapidly in recent years. There are more and more mutual funds and funds management companies in China. An empirical study is carried out to investigate the core competence of funds management companies in order to get meaningful insights.

We use balanced panel data of 32 mutual funds management companies from year 2004 to 2008 (164 observations). Types' judgment is based on funds' VaR value under asymmetry Laplace distribution in the recent 3 years. The data comes from Tianxiang System for Investment Analysis and 105 copies of investigation questionnaires collected. The evaluation results with MFDEA model are shown in Table 3.

Table 3 Evaluation results of company core competence.

Company name	Company system	Subsystem of investment and research	Subsystem of marketing and service
Jiashi	100.00%	100.00%	100.00%
Huaxia	100.00%	100.00%	74.09%
Baoying	100.00%	100.00%	68.69%
Dacheng	100.00%	100.00%	63.56%
Taidaheyin	100.00%	100.00%	53.83%
Jingshunchangcheng	100.00%	100.00%	46.59%

Penghua	100.00%	100.00%	42.59%
Huabaoxingye	100.00%	100.00%	36.93%
Yifangda	100.00%	100.00%	33.64%
Fuguo	100.00%	100.00%	32.00%
Guangfa	100.00%	100.00%	30.07%
Rongtong	100.00%	100.00%	27.25%
Boshi	100.00%	100.00%	22.59%
Xingye	100.00%	100.00%	19.47%
Gongyinruixin	100.00%	96.73%	100.00%
Nanfang	100.00%	91.96%	65.80%
Tianzhi	100.00%	89.52%	37.78%
Nuoan	100.00%	83.36%	88.67%
Taixin	100.00%	80.97%	80.92%
Changcheng	100.00%	75.41%	100.00%
Wanjia	99.84%	60.68%	9.07%
Zhongxin	98.18%	98.18%	6.70%
Huaan	98.15%	97.57%	27.31%
Jutian	95.40%	89.24%	22.10%
Jinying	95.37%	77.32%	39.53%
Haifutong	94.29%	94.29%	22.05%
Changsheng	91.12%	79.34%	56.52%
Guolianan	90.75%	88.00%	15.96%
Guotai	90.09%	79.80%	16.03%
Yinhe	81.85%	81.36%	6.09%
Guotouruiyin	73.19%	67.03%	13.90%
Yinhua	72.42%	69.16%	39.05%

As shown in Table 3, 21 companies are relatively efficient among the 32 mutual fund companies, 15 companies are efficient in investment research subsystem and 4 companies are efficient in marketing service subsystem.

Obviously in China, more than half of the mutual funds management companies' core competence are cultivated soundly. However, the marketing and service competence is dispersed greatly within the industry, which indicates that the competition in current Chinese mutual fund market is led by clients service and marketing service instead of asset management capacity. This is the main reason of core competence differences.

The evaluation results also indicate that Company Gongyinruixin and Company Changcheng are good at marketing and service, but weak in investment and research. Company Jiashi is the only one to be relative efficient in both the whole system and subsystems.

It is explicable in the reality. Actually, as one of the first batch of fund companies established in China, Company Jiashi has launched 12 mutual funds and built up a complete product system of open-end funds. It has a long history with a lot of experience in asset management. It is also the first one to propose its brand strategy, and hence, investors regard this company as far-sighted and steady advanced. It is also the only one to be able to keep better performance over the average in the past 5 years due to its moderate management. Funds such as Taihe, Wenjian, Jiashi, etc. which are under the management of Company Jiashi have provided excellent returns to their investors. Once, Fund Jiashi Celuechengzhang collected RMB 40 billion Yuan on its first day, which not only made Jiashi Fund Company the biggest mutual funds management company in China instantaneously but also brushed the initial subscription scale record in the mutual funds industry of China. Obviously, the evaluation model's results accord with the fact.

Marketing has to be guaranteed by service. When significant effect of sheep flock results in similar investment returns, service will become as importance as or even more than investment performance. Since the competition is

serious in the market, mutual funds management companies have to provide good service as well as good products to attract investors and retain them, besides improving returns.

As a part of the financial service industry, mutual funds management companies' brands are formed gradually in course of marketing and service. Good service helps to attract more clients and to strengthen their faithfulness, in order to settle solid foundation for future asset scale and upstanding business status.

In addition, good service is able to boost enterprise's social image, which also favors a company's long-term development. The more clients acquire for fund products and financial service, the larger the company's market appreciation is, the more satisfied investors will be with it. This leads to good competition competence.

6. Conclusions

Study on core competence eveluation of mutual funds management companies is a newly emerging area of research in financial management, strategic management and operations management. However, the management of mutual funds has long been the subject of assessment in the context of delegated portfolio management. In this paper, for the first time, we extend an assessment to funds management companies' core competence evaluation. With thorough investigation and analysis of mutual funds industry, we consider mutual funds management companies' core competence into two parts: investment research competence and marketing service competence, included within an whole evaluation system.

We propose a multi-subsystem fuzzy DEA model as an improvement of fuzzy DEA model of Lertworasirikul et al. [12], with wich we solve this hard evaluation problem.

An empirical study is conducted with 32 mutual funds management companies in China. The results find that, those companies display relatively high managerial skills for the most part, but competences differ a lot among themselves in marketing and service. Marketing service competence is the main reason of this gap. Some companies lag because of too small scale or too slow rate of scale increasing. One or two companies are good at marketing service but weak in investment research. The empirical study also testifies the multi-subsystem fuzzy DEA model' feasibility and reliability in mutual funds management companies' core competence evaluation.

This study of mutual funds management companies' core competence evaluation has made some important discoveries and draw management insights, not only academically but also commercially. It helps the mutual funds management companies to urderstand their own advantages and shortcomings and tells them how to improve their core competence in future.

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